SCALE MODEL SIGNING TECHNIQUE

by

GARY LEE FOX

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Major Professor

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INTRODUCTION

Alexander (1), Cumming (4), and National Cooperative Highway Research Program (NCHRP) (17) have done extensive studies on the driving task, and have determined that it consists of three subtasks: control, guidance and navigation. Control relates to the driver's interaction with his vehicle and has two distinct elements--steering control and speed control. The driver receives necessary control information in the form of feedback from the control mechanisms (steering wheel, brake, and accelerator) of the vehicle itself. Guidance refers to the driver's ability to maintain a safe path on the highway. The driver receives guidance information from two sources: 1) the highway--its geometry, markings, and signs; and 2) other traffic--speed, relative position, lane changes, etc. Navigation refers to the driver's ability to plan and execute a trip from its origin to its destination. Navigation information comes from such sources as maps, landmarks, and guide signs.

In the early days of automobiling, the task for the driver was often more physical than mental, and human performance requirements were based on the strength necessary to operate the starting handle, the tiller, and the wheel brake. The physical demands of the driving process now fall within the capabilities of almost all of the non-bedridden population. Investigators of the driving process commonly regard the driver as primarily an information processor with secondary physical strength capabilities used to interact with the vehicle controls and the environment.

History and Development

When man first began using the automobile, the demands placed on the driver as an information processor were minimal. His trips were usually short, which kept the driver in familiar territory. In addition, there were very few other vehicles to contend with. In 1900, only 8,000 motor vehicles were registered in the United States (12). By 1930 there were approximately 3 million miles of roads and almost 27 million registered vehicles in the U.S. By 1961 the highway and street network included over 3.5 million miles and served nearly 80 million vehicles, with an estimated number of vehicles over 100 million by 1975. An increasing dependency on the automobile and related forms of travel to serve the transportation needs of the United States has caused this trend of propagation, particularly the number of vehicles, to continue to the present day, with no apparent break in the near future.

A dramatic increase in simple numbers has not been the only trend. Old models of automobiles, and trucks and busses as well, have consistently given way to bigger and more powerful new models. It is only recently that this trend in automobiles has apparently peaked, with a significant number of smaller, less powerful cars on the market today.

The physical design of the highways and roads has adequately complemented the design of faster vehicles. Where once the automobile floundered in the mud and speeds in excess of 20 mph were considered breakneck, today's cars seldom travel on anything but a paved surface, and speeds of 70 mph on the newer (and sometimes not so new) highways are commonplace. In addition to these surface and alignment improvements, the roadway network has become vastly more complex.

Highway signing has not escaped the influence of the developments in vehicles and the road system. In the pre-automobile days, information concerning established trails and routes was extremely basic. With the advent of the automobile, problems which for centuries had been benign and almost academic became complex and urgent. Local networks of roads were integrated into statewide systems and then into interstate connections. Route numbers and names evolved slowly, but signs were sparse and inconsistent.

The State of Wisconsin was a leader in the evolution of highway signs. In 1918, Wisconsin's roads were marked according to a systematic plan, and maps were prepared with roads identified by number. Most early signs and route markers were painted on telephone poles or affixed or painted on structures along the roadway. Wisconsin became the first state to use baked enamel markers on sheet metal, supported by relatively light standards. In 1924, the American Association of State Highway Officials urged the creation of a comprehensive interstate route system, the development of a "uniform scheme for designating such routes," and recommended adoption of uniform signing practices.

In 1936, the first Manual on Uniform Traffic Control Devices was compiled, and has been systematically revised through the years. The new edition of the Manual (11) was approved by the Federal Highway Administrator on November 13, 1970, as the National Standard for all highways open to public travel. This edition recognizes and regulates the design and placement of traffic signals and pavement markings in addition to three classes of signs: guide signs, warning signs and regulatory signs. This uniform regulation has been made imperative by the vast number of traffic control devices required to direct the motorist through the complex highway and street network. Roadside advertising in the form of signs and billboards has become perhaps more extensive than the traffic control devices, but is much less stringently controlled or regulated.

The three driving subtasks have been greatly affected by these developments. Control has been made easier by improvements in the vehicles and their handling characteristics. Guidance has, on the one hand, been aided by better highway and pavement designs and markings, but, on the other hand, been complicated by the increase in competing traffic and higher speeds. Navigation has been made more difficult by the increasing complexity of the highway network and the accompanying increased use of traffic control devices. Since the total driving task consists of the simultaneous performance of the three subtasks, the overall effect of the developments in highway travel has been to complicate the total driving task by presenting the driver an increased amount of information to analyze.

Information Processing

The amount of information which the driver must analyze is not a simple linear function of the information density. It is instead a function of the information rate which is the product of information density and speed (10). The increase in information densities and the concurrent increase in speeds have combined to produce a multiple increase in the information rate the driver must process.

But man is, rather unfortunately, not a multi-channeled parallel processor--he can do only one thing at a time. For most practical purposes, human operators can only accept data through three sensory channels: 1) visual (seeing); 2) auditory (hearing); and 3) kinaesthetic (motion and force sensing). Of the three types of sensory stimuli, visual requires both attention (being prepared to see the visual stimulus) and location (determining the source of the stimulus) and, in addition, is the slowest and most easily lost. Man again appears to be unfortunate in that he must receive most of the information necessary to successfully perform the driving task through his visual sensory channel.

The concept of man as a sensor-processor-actor system is illustrated in Figure 1.

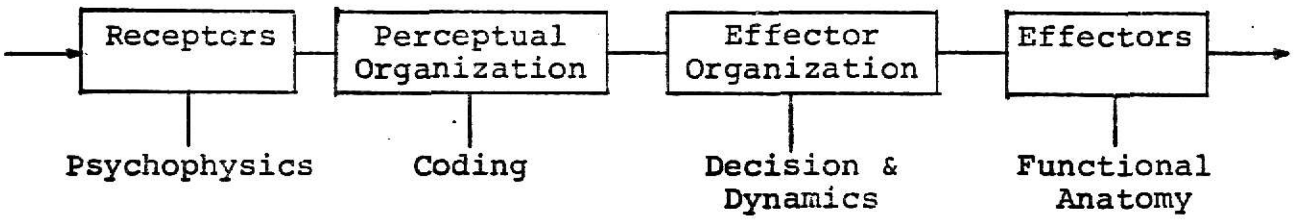

Figure 1 - Human Information Processing Model According to Easterby (9).

According to this scheme, the information input is picked up by the receptors (visual, auditory, and kinaesthetic). Next, the information is perceptually organized, and meaning assigned to the organized bits of information. Then a decision is reached as to the appropriate response to this information, and finally the response is enacted by the functional anatomy of the body (hands, arms, vocal cords, etc.).

In the simplest situation, where one specific stimulus leads to only one specific response, there is no uncertainty involved, and the required decision is said to be a zero-bit decision. Cumming (4) has found that the simple reaction time for a visual stimulus is 0.18 second, and for an auditory or kinaesthetic stimulus is 0.14 second. The driver seldom faces this simple situation, but instead must make a choice between a number of equally probable alternatives for which there is a corresponding number of bits of uncertainty. Reaction time increases as both the number of equiprobable alternatives and the number of bits of uncertainty increase. This relationship is shown in Table 1.

Table 1*

Derivation of Rate of Decision Making and Information Handling

Number of Equiprobable Alternatives (2^n)	Uncertainty in Each Decision (n bits)	Reaction Time (sec.)	$\frac{1}{\text{Reaction Time}}$ (decisions/sec.)	Maximum Rate of Handling Information (bits/sec.)
1	0	0.187	5.35	0
2	1	0.316	3.16	3.16
5	2.32	0.487	2.05	4.76
10	3.32	0.622	1.62	5.38
32	5	0.845	1.18	5.92
64	6	0.972	1.03	6.18
128	7	1.105	0.91	6.34

*Cumming (4)

Notice that the number of decisions which can be made per second falls off rapidly as the number of equiprobable alternatives increases from 1 to 5, and the rate of handling information increases rapidly as the uncertainty increases from 0 bits to 2.32 bits. For the driver, operating in a dynamic situation, a high rate of decision making must have a very limited number of possible responses for each decision. And concurrently, a high rate of information handling is possible by requiring fewer but more complex decisions.

Capacity limits. But events can occur in the driving situation where the rate of information and the complexity of decisions are both high. NCHRP Report 123 (17) found that presenting the driver with excessive information may cause his channel capacity to be surpassed. Channel capacity is defined as an "asymptotic value where an increase in the input of quantity of information yields no increase in the transmitted quantity of error-free information."

So there is a limit to the human capacity for handling information (or for resolving uncertainty). This limit is linked to the rate of demand. The relationship between the rate of information processed by a person and the rate of demand is illustrated in Figure 2.

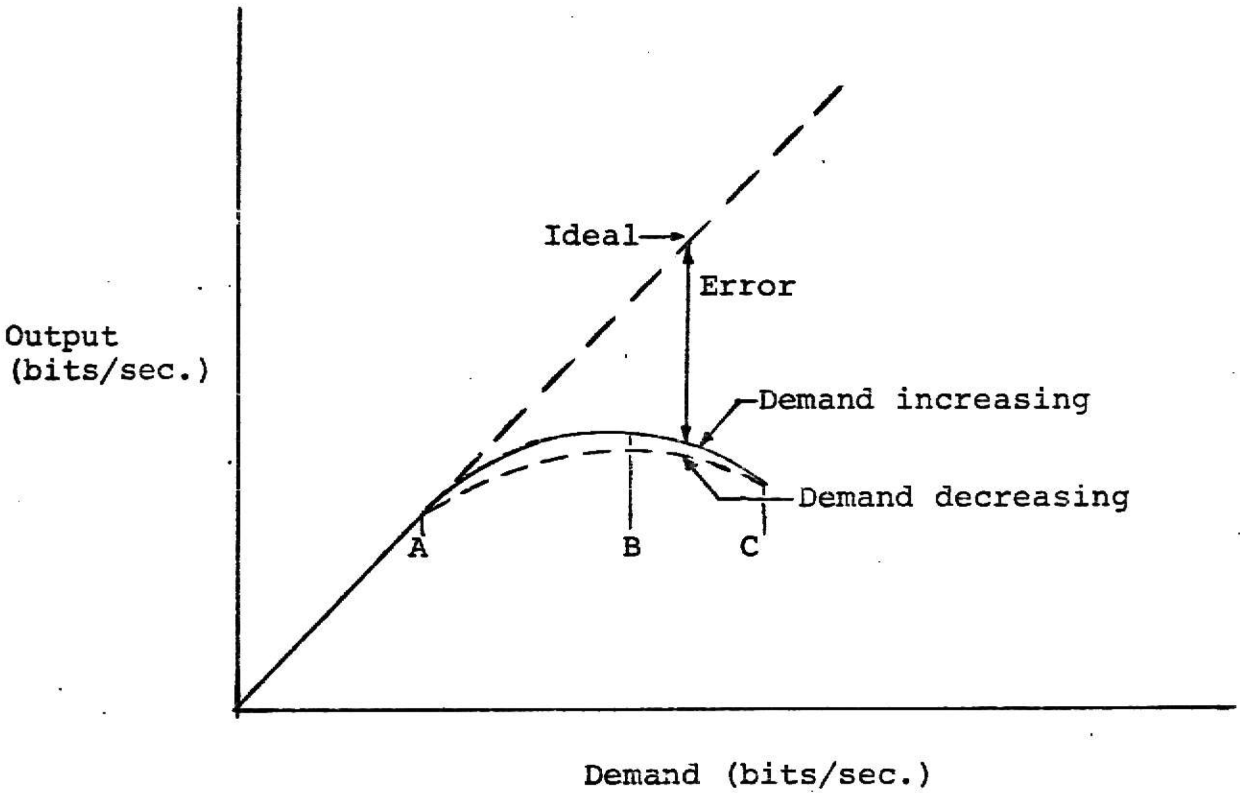

Figure 2 -- Conceptual Model of the Human Information Transmitter According to Cumming (8).

Up to a certain demand (A), the output is equal to the demand, and processing can occur without error. As the demand increases, the output falls progressively below demand. This difference between the demand and the ideal rate of output is error, in the form of wrong decisions, missed information, or information selectively shed by the person faced with too much to cope with. As the demand increases past point B, the output begins to decrease, and the person is said to be overloaded. If the person is significantly overloaded, as at point C, there can be a residual effect on his output even after the demand is reduced, as shown by the dotted line (demand decreasing) from C to A.

<u>Stress</u>. In addition to the human characteristic of capacity limits, there is a relationship between performance and stress, as indicated in Figure 3.

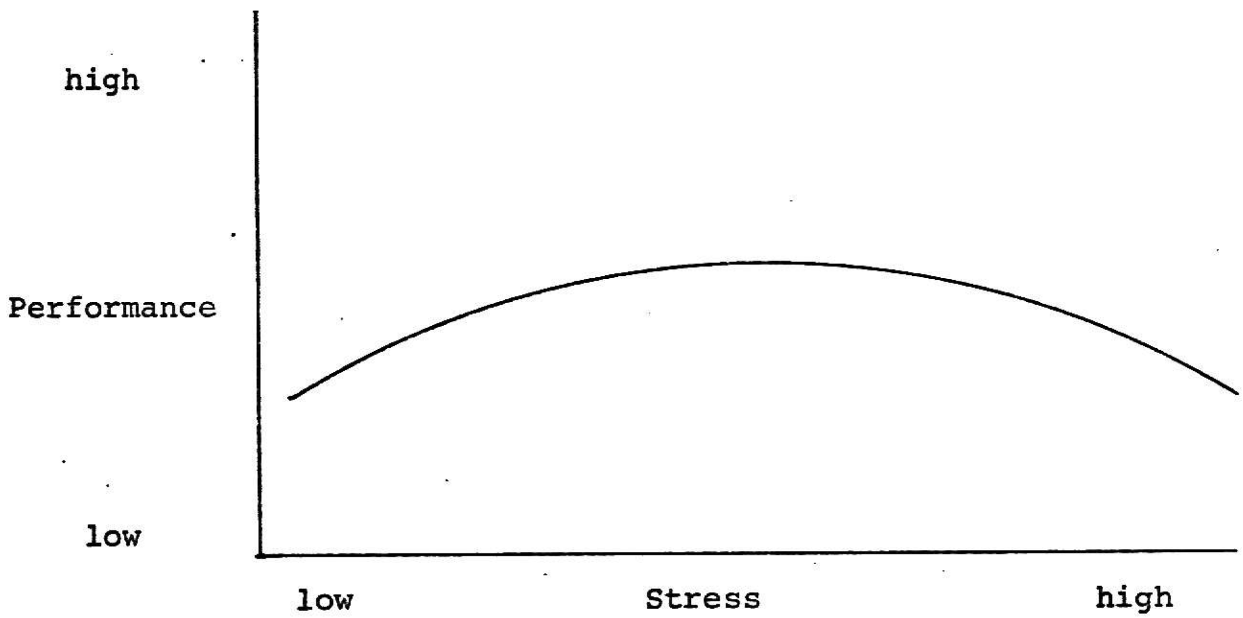

Figure 3 - <u>Effect of Levels of Stress on Performance According to Cumming (5)</u>.

As a general concept, people perform better when moderately stressed, and their performance falls off when the stress is either too high or too low. The stress may be induced by the task itself or may be extraneous to the task (worry, discomfort, state of health, fatigue, and effect of drugs and alcohol).

The rate of demand is a common source of stress in the driving task. When the rate of demand is low, the driver's alertness becomes low, and his performance is reduced. NCHRP Report 123 (17) found that when the demand rate is too low, as on a long linear alignment with monotonous scenery, drivers may create their own demand by turning on the radio or by varying speed and making unnecessary lane changes.

Expectancy. Another important concept in human behavior relates to the process in which an individual with an established set of ideas and concepts is presented with a stimulus of some type (visual, auditory, or tactile) and responds in some fashion to this stimulus. The set of ideas and concepts is very influential in determining the nature of the individual's response to the stimulus, and is referred to as his expected set or "expectancy." This concept is presented in Figure 4.

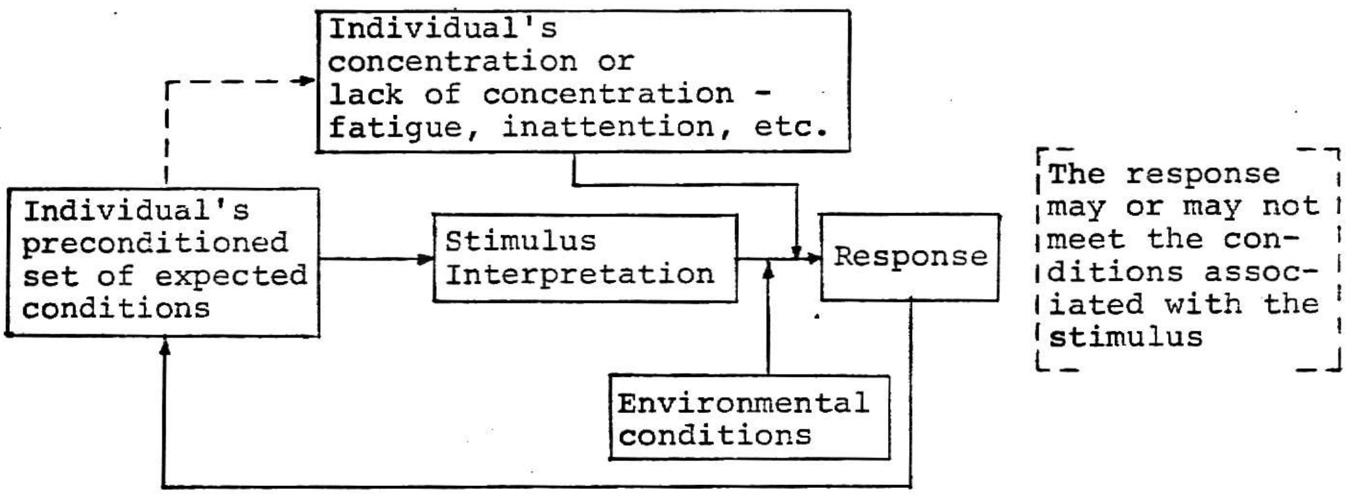

Figure 4 - Simplified Expectancy-Response System According to Woods (21).

The individual's concentration, or lack of concentration, reflects his alertness, while fatigue, inattention, etc., represent stresses external to the driving task. The environmental conditions reflect the rate of demand or the stress created by the task itself.

Notice that the response does not necessarily meet the conditions associated with the stimulus. Alexander (1) states that "when a driver's expectancy is incorrect, either it takes him longer to respond properly or, even worse, he responds poorly or wrongly." So the response may be actuated by the expected conditions rather than the given stimulus conditions.

Information Gathering

Given these characteristics of the human operator as a sensor-processor-actor system, an obvious question arises: What can be done to improve his performance? As a sensor, one of the most important driving skills is the skill of systematically and efficiently gathering information (17). The driver's ability to perform, especially in high-signal, high-speed situations, depends on his ability to time-share his attention among the competing information sources and focus his attention on the most important information needs.

Many drivers perform this process of information gathering inadequately. Johannson and Backlund (14) have found that the overall probability of a road sign being noticed on passing is not higher than about 0.5. For different types of signs, the probability ranged from a low group of 0.25 to a high group of about 0.75. Variations in the road conditions, visibility, and traffic density had no significant effect on the probability of recording a correct response.

The location of the stimulus in the visual field becomes an inportant factor in the efficiency of sensory input. Kobrick (15) and Kobrick and Dusek (16) have found that as signals become more and more peripheral, subjective response time increases. This is further aggravated by introducing a secondary central task of a perceptual or of a perceptual-motor nature that engages subject attention in the central field while peripheral capacity is being monitored. Since the driver's attention is of necessity directed primarily toward the roadway, placing signs as near as possible to his field of central vision should increase his efficiency.

Sign Legibility

Legibility of signs is also an important consideration in the driver's sensing visual stimuli. Letter width, stroke width, spacing between letters, proximity of borders and other lettering, contrast between colors, brightness between lettering and background, and general level of brightness all affect legibility. The driver will be more effective in recognizing signs if the optimum conditions for legibility are present in the sign. In addition to the legibility of signs, their shape is also important. Lees and Farman (10) found that the shapes which are most distinctive and recognizable are those that have the most acute angles: triangle, pennant, and trapezoid. The same study also determined that the superiority of a positive presentation (black figures on white images) was quite clear and held true for every shape, and that the introduction of color causes no drastic changes in recognition of shape.

But color is an important characteristic of visual stimuli. Bertone (2) found that "warm" colors (red, orange, yellow) should be used in danger situations and "cold" colors (green and azure) for safe conditions and general text. Even the smallest border or frame increased the legibility of signs, and brightness contrast played the dominant role in legibility for combinations of colors.

All of these factors have been concerned with improving the visual qualities of the informational sources the driver relies on. They are not, however, the only means of aiding the driver.

<u>Driver Capabilities and Traffic Situations</u>

Cumming (6) describes a continuum, ranging from simple to difficult, on which a distribution of traffic situations and a distribution of driver capabilities can be plotted, as in Figure 5.

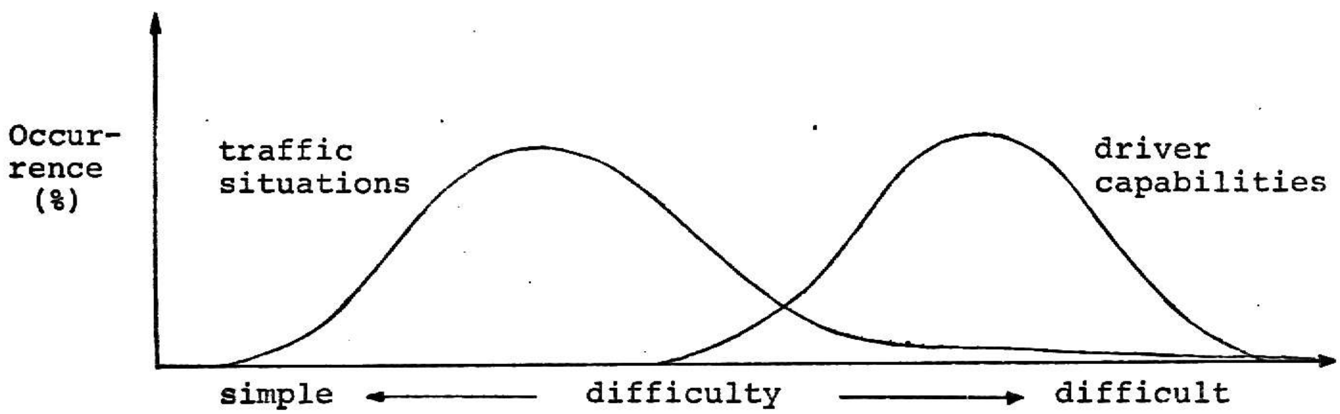

Figure 5 - <u>Conceptualized Model of Difficulty Distributions</u>.

As can be seen from the model, driver capabilities are distributed in the community approximately in accordance with a normal distribution, and the traffic situations can also be approximated by a normal distribution. The area in which the two distributions overlap represents situations in which the difficulty of some traffic situations exceeds the capacity of some drivers, and the potential for an accident exists. Whether an accident actually occurs depends on other probabilities of traffic complexity.

The occurrence of accidents should be minimized when the overlap between the two distributions is minimized. (The overlap can never be eliminated; i.e., there will always be some traffic situations which are beyond the capabilities of the best driver.) It is apparent that there are two basic approaches to minimizing the amount of overlap. One approach would attempt to reduce the difficulty of ordinary traffic situations (i.e., decrease its mean) and minimize the difficult situations (i.e., reduce its variance and mean). The other approach would attempt to increase the mean and reduce the variability of the driver capabilities distribution by minimizing the occurrence of low capability drivers. The most effective attack would utilize both of these approaches.

Driver capabilities could be enhanced by an effectively applied program of driver training, and the distribution could be truncated on the lower end by more stringent issuance of licenses. Strict enforcement to keep drivers whose capabilities are impaired by drugs and alcohol off the highways would also have a positive effect on the distribution.

There appears to be more promise for changing the distribution of traffic situations, since all of the factors which contribute to the distribution (the road system, the vehicles, and the rules which govern them) are man-made and thus are subject to design and manipulation. Vehicles can be made safer and ambiguous traffic rules can be modified. Road systems can be designed to higher standards of safety.

Spreading. The presentation of information to the driver (through signs, signals, and pavement markings) is an integral part of any traffic situation. Alexander (1) states that one method of reducing the complexity of a traffic situation is "spreading." By the concept of spreading, all extraneous information is removed from areas which are already presenting the driver with a high information rate and spread out to areas of much lower information densities. For example, a driver should not be presented information concerning motorist services at the same point he is trying to determine the proper exit; service information should be presented far in advance of the exit. By the same token, the information concerning the exit should be presented enough in advance of the exit so the driver, at the critical point of the junction of the exit and the roadway, can devote his full attention to the control of his vehicle and its position relative to the other vehicles. This helps reduce the stress on the driver as an information processor, and allows him to perform more efficiently.

Expectancy. Another concept which helps the driver select the information which he needs is "expectancy." In a study on pavement markings, the Texas Transportation Institute (19) found that "....the driver develops an expected operational situation. A driver seeing markings which are familiar assumes that his interpretation of the operational situation is correct and does not attempt to gain further information, even though it may be available." If a consistency of markings is applied to each operational situation, it seems reasonable that the driver will assume the proper expected situation. It is then much easier for him to make the proper maneuver when his expectation is met. Unfailingly meeting drivers' expectations can be a powerful tool in helping his performance in the traffic situation.

Coding. Alexander (1) describes "coding" as one more effective tool in aiding the driver as he attempts to process the vast amounts of information with which he may be confronted. Coding is a method of information presentation which organizes bits of information into a larger unit and uses a symbol to represent the unit. Coding recognizes man's limited ability to process information, and it presents much information on a single, simple source. A good example of coding is the Interstate route shield, where the shield shape and red, white, and blue colors designate the route as a high-type facility, with no at-grade intersections and no railroad grade crossings. In addition to the shield shape and the colors, the number relays much information.

Routes ending in an odd number are north-south routes, while those ending in an even number are east-west routes. Routes ending in 0 are coast to coast, while those ending in 5 are border to border. Low odd numbers place the highway on the west coast (I-5 from San Diego to Seattle), while the numbers get progressively higher as the geographic area becomes more easterly (I-95 from Washington to Richmond). Similarly, I-10 connects Southern California to Florida, while I-90 connects Seattle and Boston. Three digit numbers denote a link or bypass around a city where the actual Interstate goes through the city (I-470 bypass around Topeka on I-70).

Information System Failures

While coding, spreading, and meeting driver expectancies are useful techniques for presenting information to the driver, it is the proper application of these techniques that can maximize their effectiveness. However, these techniques are not always utilized effectively, as is noted in a report by the Texas Transportation Institute(19):

"Currently, one of the technological constraints which is appreciably influencing the safety and efficiency of traffic operations is the lack of an integrated set of design standards for all the elements of the visual communication system of a roadway. This deficiency makes it very difficult to effectively transmit to the driver information which is necessary for the guidance, warning, and control of traffic."

In a subsequent report, Texas Transportation Institute (20) further defines the cause of information system failures: "The difficulty of visualizing a three-dimensional, finished facility during the design process, as well as differences in interpretation of the existing standards, have been identified as the primary reasons for failure of the information systems on newer facilities."

Design Aids

With the cause for information system failures defined, logical solutions can be established. One vital aspect of the solution would be an integrated set of design standards, and standardized interpretation of those standards. A second, equally important aspect would be design aids to help the designer visualize the three-dimensional, finished facility during the design process. The Institute of Traffic Engineers Report (13) mentions three major categories of such design aids: 1) computer perspectives; 2) design models; and 3) pictoral methods (i.e., artists' sketches and sketchboard drawings).

Design models. Of these three techniques, the design models represent probably the most realistic and comprehensive aid to the designer. These models, when constructed to the proper horizontal and vertical scales, provide a three-dimensional view of the physical features of the roadway. While sophisticated detailing of the roadway environment can enhance the realism achieved, such detailing is not required to produce an effective design model.

PURPOSE

The purpose of this study was to develop a technique for viewing highway signs in a scale model. This technique involved three phases: 1) constructing the basic roadway model; 2) making scale model signs; and 3) viewing the signs in the basic model through a modelscope.

METHOD

In order to have a basis for evaluating the finished model a section of existing roadway, complete with signs, was selected for the basic model. Again for comparative purposes, the existing signs were scaled to the proper size and placed in the basic model. In addition, new signs were designed and scaled for the model.

Three methods of viewing the model with signs through a modelscope were considered: 1) viewing with the naked eye; 2) still photographs, both color slides and color prints; and 3) video camera to better simulate the dynamic nature of the driving task.

Modeling Technique

Basic model. First, the basic model was constructed, using the procedure in the Institute of Traffic Engineers Report (13). Design blueprints were obtained to determine the horizontal plan and the vertical profile of the roadway. These blueprints were drawn at a 50-scale (1"=50'), which fixed the model at the same scale, both horizontally and vertically.

A reproduction of the plan was pinned to a three-inch thick styrofoam base. Roadway and ramp profiles were plotted on one-half inch thick sheets of urethane, cut out with a sharp razor-type knife, and attached to fit the horizontal plan on the styrofoam base. A roadway surface was cut out from gray-finish .015-inch paper pressboard, and lane lines drawn using a flexible plastic "spline line," drafting pen, and white ink. The roadway surface was placed on the urethane roadway and ramp pieces, and attached with straight pins to conform to the scaled horizontal plan and vertical profile. This completed the basic model.

Existing signs. The scale model signs were produced by photographic reduction. Pictures were taken using the Nikon F, 35 mm camera and lenses owned by the Civil Engineering Department, Kansas State University. The existing signs were photographed at their actual location, and at the desired scale.

The size of the sign was measured and the proper scaled size calculated (for a 50-scale, a sign ten feet wide would result in a model sign 0.2 inches wide). The head of the camera was removed, exposing the ground glass, and the distance from the sign to the camera changed until the sign image on the ground glass, measured with a flexible plastic scale, was the desired size.

Two slightly different techniques were tried in order to produce a high quality picture for use as a scale model sign. First, color slides were taken of the existing sign at a scale of one inch equals 50 feet, using Ektachrome-X, CX 135 film. The film was developed but not mounted in slide frames. The unmounted slides were then firmly pressed onto a Polarcolor print mount. Six slides were mounted on each print mount. The signs were carefully cut out and glued to straight pins.

The main drawback to this technique was that mounting the slides on the print mount caused severe darkening of the picture. Even when the slides were overexposed one f-stop on the camera, the finished signs were too dark to be easily read. Longer overexposure would likely have produced a finished sign of the desired brightness, but a slightly different technique proved to be easier.

Pictures of the existing signs were taken as before, but on color print film instead of color slide film. Kodacolor-X, CX 135 film was used, resulting in a minimum print size of twice the negative size. Therefore, the image on the ground glass, which is the same size as the image on the film, had to be scaled to one half the finished sign scale. In this case, a scale of 1"=100' was used. The signs were carefully cut out, mounted on print mounts, and glued to straight pins as before.

Design of new signs. The new signs were constructed to conform closely to the guidelines for signing in the Manual on Uniform Traffic Control Devices for Streets and Highways (11). Craftint COLORMATCH paper, Green Hue number 161, closely matched the specified green background color. Machine cut white poster-board letters were glued to the green background to form the legend. Three-quarter inch letters were available, and the signs were scaled to make this letter size correspond to the desired letter height.

Directional arrows were hand cut from white posterboard, and glued to the green background. An Interstate highway symbol of the appropriate size was cut out of the Manual and glued to the sign. The Highway 291 symbol was cut out from white posterboard and the black lettering added by hand. One-eighth inch wide white Zip-A-Line tape was used to form the border around the sign.

These signs were photographed in natural sunlight (to match the conditions for the existing signs), using Kodacolor-X, CX 135 film. Since the signs were constructed to scale, the actual sign width was known, and the photograph scaled on the camera ground glass as before. Signs on the developed prints were cut out and mounted for placing in the model.

The support for the overhead sign was made by bending a paper clip to fit over the model roadway at the desired location. The signs were mounted on the paper clip similar to mounting on the pins.

Another method for designing signs was considered, but due to difficulty in getting the materials, has not been used. The same green Craftint paper would provide the background. Letters could be added by using white chartpak pressure-sensitive letters. Helvetica Medium style very closely resembles the series E alphabet, and at a scale of 3/8-inch equal to one foot, the 48 point letters would provide sixteen-inch upper case and twelve-inch lower case lettering.

Letter sizes and spacing would be determined from an appropriate signing manual. Directional arrows would be hand-cut from white posterboard. White pressure-sensitive tape would be used for the borders. Patterns for route shields would be designed to scale, the shields cut from the desired color of Craftint paper, and black or white pressure-sensitive numerals and letters added. These signs would then be photographed to scale, mounted, and placed in the model.

Modelscope Viewing

The scale model signs were placed in the basic model to correspond to the actual sign locations, determined by roadway stationing. The HCI modelscope owned by the Civil Engineering Department at Kansas State University was used to view the model.

Naked eye. The eyepiece was attached to the modelscope to allow direct viewing of the model and signs with the naked eye. A small rolling dolly was constructed to permit the modelscope to be moved easily down the roadway, simulating the view from a moving vehicle.

A one-inch long, half-inch wide, three-eighths-inch thick piece of clear plastic was used for the dolly. A hole was drilled through the length of the plastic near one edge, slightly smaller than the diameter of the modelscope shaft. This hole was reamed out with a small hand file to provide a snug fit for the modelscope. Plastic covering the modelscope lens was cut away, providing an unobstructed view through the lens.

Small rubber toy-car wheels were added by drilling a small hole through the thickness of the plastic, placing the metal axle through the hole, and attaching a wheel to either side. The hole was drilled slightly larger than the axle to permit free turning. A sketch of this dolly is shown below in Figure 6.

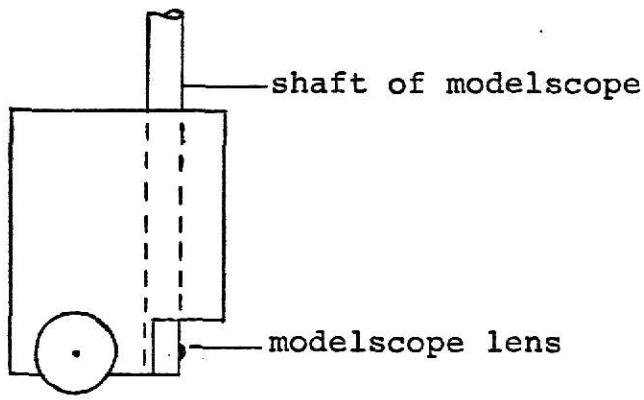

Figure 6 - Dolly for Modelscope.

Still photographs. The Nikon F, 35 mm camera was used for taking pictures through the modelscope. The modelscope was attached to the camera lens by a three-piece adaptor ring, included with the modelscope. Also, a spacer was placed between the camera and lens for some pictures. This camera-modelscope arrangement is shown in Figure 7 (see next page).

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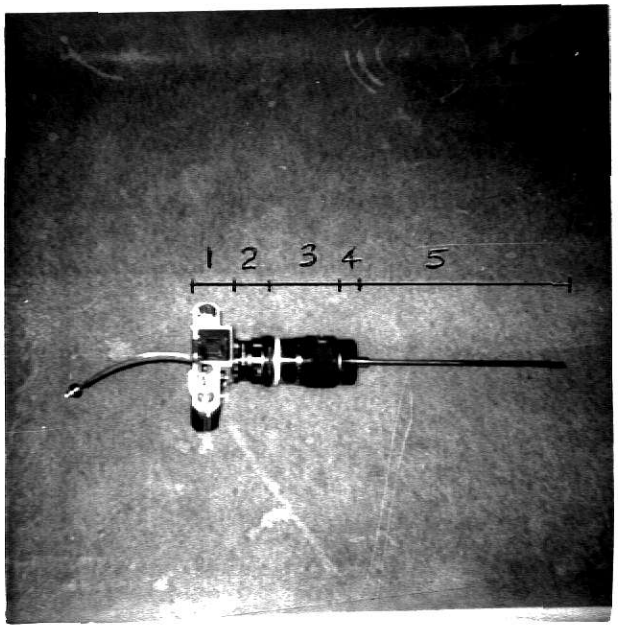

1 - camera
2 - spacer
3 - lens
4 - adapter ring
5 - modelscope

Figure 7 - Camera with Modelscope and Attachments.

One 500-watt, 3200-degree Kelvin tungsten filament flood lamp was used to provide lighting. The light was positioned at a 30-degree horizontal angle and 30-degree vertical angle from a line perpendicular to the face of the sign being photographed, at a distance of two feet from the sign. To minimize vibrations the camera and modelscope were attached to an adjustable tripod, and a short cable release used to operate the shutter, as shown in Figure 8 (see next page).

Figure 8 - Set-up for Modelscope Pictures.

Two 4-foot by 8-foot by 3-inch pieces of blue styrofoam were placed on two sides of the model to provide a neutral background and help reflect light. The styrofoam base was blocked up to a comfortable working height (four chair seats worked well). The tripod was adjusted for the desired modelscope position and pictures taken.

For color slides, High Speed Ektachrome EHB - 135 film was used, and for color prints Kodacolor - X, CX 135 film was used. Different combinations of focal lengths and exposure times were tried. The camera head and ground glass were removed, showing a clear image of the modelscope view.

Video film. A SONY Video Camera, model CVC-2100A, and SONY Videocorder, model CV-2100 were borrowed from the Human Factors

Lab at Kansas State University. The modelscope was attached to the camera lens by using only two pieces of the modelscope rings, as shown in Figure 9.

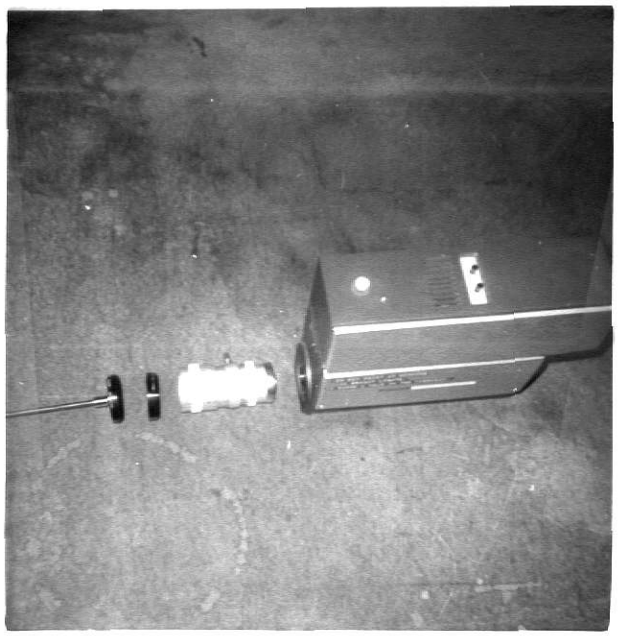

Figure 9 - Video Camera and Modelscope.

The video camera was fixed to the tripod and set in position in the model. Two 500-watt, 3200-degree Kelvin tungsten filament flood lamps were used to provide light. This arrangement is shown in Figure 10, page 28.

In addition, the plastic dolly was attached to the modelscope and the camera hand-held to obtain a video film of simulated driving over the roadway.

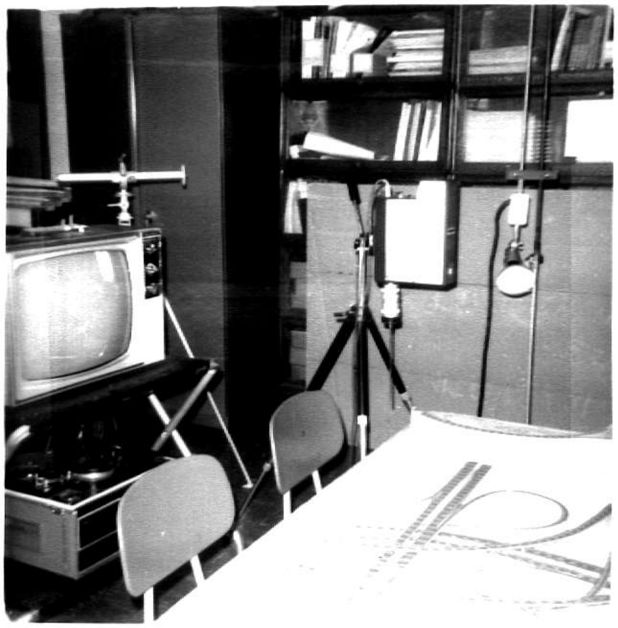

Figure 10 - Set-up for Video Camera.

RESULTS AND DISCUSSION

Modeling Technique

The basic model of the roadways appeared realistic when viewed through the modelscope. Simulation of ground contours by using dyed green sawdust or some similar material would have enhanced the realism achieved, but was not considered necessary for the purpose of this study.

Several findings during the development of the sign modeling technique were considered significant. The use of color print film instead of color slide film for making the scale model signs had several advantages:

1) It was not necessary to try different amounts of overexposure to get a good quality sign;

2) The color negative was still intact for making additional prints, which were later used to compare actual sign photographs with scale model photographs, while the color slide could not be reproduced after it was cut up. (However, the slide could be used to make prints before cutting out the sign);

3) The mounting procedure was generally easier for the signs on color prints;

4) Model signs made from color prints (with non-glossy finish) were less likely to glare under the high level of lighting required for photographing through the modelscope.

The vertical and horizontal angles of the light source from the face of the sign were also important. Angles too close to an imaginary line perpendicular to the face of the sign caused glare.

The technique of using white pressure-sensitive letters for the design of new signs, while as yet untried, appears to offer a significant improvement over the machine-cut letters. The machine-cut letters were so different from any acceptable signing alphabet that they would be totally unacceptable for designing new signs. However, due to the difficulty in obtaining the pressure-sensitive lettering materials, the machine-cut letters were necessary in developing the photographic reduction technique for the scale model signs.

The Helvetica Medium style of lettering, with proper letter spacing and borders, would permit accurate design of new signs.

Also, the pressure-sensitive letters would be much easier to apply. The only disadvantages appear to be difficulty in obtaining the lettering (it must be special ordered) and a short shelf-life caused by deterioration of the lettering material.

Modelscope Viewing

Naked eye. Modelscope viewing with the naked eye gave very good results. The modelscope presented a clear view with no need for special lighting. There did not appear to be any distortion of colors, and focusing was sharp.

The main drawback is that there is no means of retaining the results or presenting them for simultaneous group viewing. The advantages of high quality viewing, easy use, and eliminating the expense and delays involved with still photographs and video film make naked-eye viewing of scale model signs through a modelscope a desirable and effective design aid.

Still photographs. Figure 11, page 31, compares signs photographed at location and model signs photographed through the modelscope. Modelscope pictures are prints made from color slides, taken on High Speed Ektachrome EHB - 135 film. Camera settings were: focal length of 86 mm; aperture setting of 3.5; depth of field of four feet; and an exposure time of two seconds.

Since the design models are constructed as design aids to help visualize the finished facility during the design process, and not generally for public presentation, detailing of the external environment is not usually done. If just the roadway

Figure 11 - Actual Location Signs (left) vs. Model Signs (right).

and signs are compared, the modelscope pictures compare favorably with the actual location pictures.

Pictures taken through the modelscope were slightly out of focus. This resulted because the modelscope has a focal length of 20 inches (500 mm), while the camera lens has a minimum depth of field of four feet. Also, the focal length of 86 mm seemed to cause a longitudinal exaggeration of distance, making objects appear farther away than they would with the naked eye.

A second group of pictures was taken to obtain sharper focusing and a better lens focal length, using Kodacolor - X, CX 135 film for color prints. Figure 12 (see page 33) was taken through a 95-205 mm zoom telephoto lens, set at a focal length of 150 mm, aperture setting of 6.3, depth of field of six feet, and a two second exposure time. A three-piece spacer ring was placed between the camera and the lens to help match the modelscope focal length of 20 inches (see Figure 7, page 25).

Figure 13 (page 33) was taken with the same camera settings except a focal length of 205 mm and an exposure time of four seconds. The 150 mm picture was taken two inches from the sign, while the 205 mm picture was taken four inches from the sign.

The signs in the two pictures appear to be the same size, but the roadway and lanes in the 205 mm picture are much wider. Because the 150 mm focal length does not overfill the picture and thus gives a wider view, it is probably the better focal length to use. More work comparing actual and scale model signs, taken from equivalent distances, should be done to determine the best focal length.

Figure 12 - Modelscope Picture, f = 150 mm.

Figure 13 - Modelscope Picture, f = 205 mm.

Figure 14 is a picture of the same sign taken on High Speed Ektachrome EHB - 135 color slide film. A lens focal length of 86 mm and an exposure time of one second were used. Several differences were noticed between prints from color slides and color prints from color film. The color slide Ektachrome EHB - 135 film is balanced for the tungsten filament flood lamps used for lighting, and gives good color reproduction. The Kodacolor - X, CX 135 film for color prints is balanced for natural sunlight or blue flash bulbs and gives a yellowish tinge when used with the tungsten filament flood lamps.

Figure 14 - Modelscope Picture, f = 86 mm.

Good color reproduction should be achieved by photographing in natural sunlight, using blue-colored flood lamps, or using a special blue filter ring on the camera. As of this date, there is no readily available commercial film for color prints that is balanced for tungsten filament flood lamps. It should also be noted that the same factors apply when making the scale model signs by photographic reduction. Unless these signs are photographed in natural sunlight or with blue flash bulbs, color distortion will result.

Also, exposure time varies with type of film, focal length, and color of the sign being photographed through the modelscope. With type of film, lighting, and sign color all held constant, a one-second exposure for 86 mm focal length, two-second exposure for 150 mm, and four-second exposure for 205 mm would result in pictures of approximately the same brightness. Other factors being equal, a one-second exposure time for a green background sign is approximately equivalent to a two-second exposure for a brown background sign. Also, the High Speed Ektachrome EHB - 135 film requires a somewhat (about 1/3) shorter exposure time than the Kodacolor - X film.

With the tripod arm fully extended, the weight of the camera caused the tripod to be unstable. Fully extending the tripod legs increased the stability. Some form of counterbalance weight would be useful for further stabilizing the tripod.

Also, it was found that keeping the modelscope either parallel or perpendicular to the camera was important (see Figure 15 below).

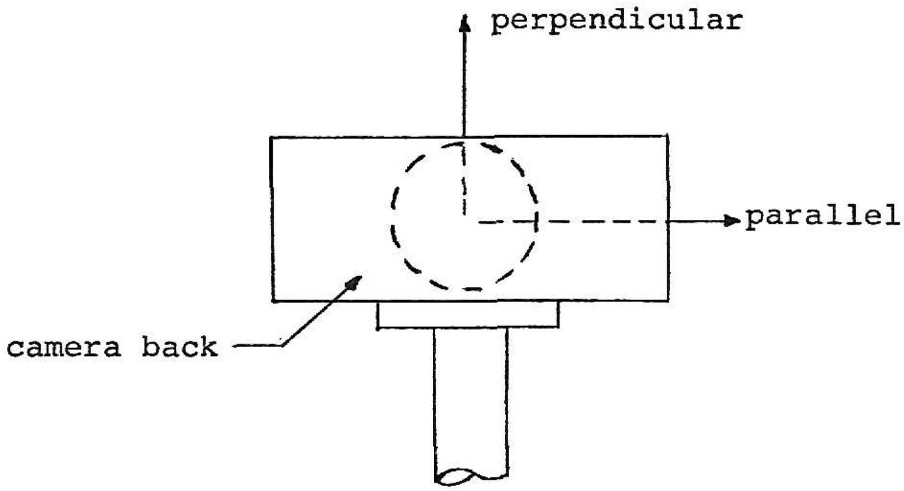

Figure 15 - Line of Sight for Modelscope.

With the modelscope lens pointed perpendicular to the camera, the image is properly oriented on the film (a 3½-inch by 5-inch print would have the long side in the horizontal plane and the short side vertical). When the lens is pointed parallel to the camera, the image is rotated 90 degrees on the film, as in all pictures in this report. Either position is acceptable, but any other position will cause the modelscope image on the picture to be tilted.

Combining all the findings above, the best picture should be produced with the following settings:

lighting - one 500 watt, 3200 degree Kelvin tungsten filament flood lamp

lens - - - focal length 150 mm
aperture setting = 6.3
depth of field = 6 feet

film - - - High Speed Ektachrome EHB-135

spacer - - three-piece spacer between lens and camera

exposure - two seconds

Kodacolor - X, CX 135 color print film could also be used, but would require blue colored lighting or a blue filter ring. Color slides are recommended as they are cheaper and could be projected on a screen for group viewing. Either type of picture would provide a high-quality, effective design aid.

Video film. Poor results were obtained with the SONY Video Camera, primarily because it was not possible to get enough light through the modelscope lens. An improved modelscope which would pass more light would help considerably. Also, filming in natural sunlight might provide enough light, but would require special protection from wind and moisture. This would also require excessive moving of the model which, while not impossible, would not be convenient.

Color video equipment would be almost essential, but would be even more expensive than black-and-white. Also, a spacer would probably be required to match the modelscope focal length of 20 inches for sharp focus. Continuous motion through overhead signs and overpass structures would be somewhat difficult but could be attained by using the editing facilities of the videocorder.

Although not achieved in this study, continuous motion film is considered to be an important improvement for viewing scale model signs. Improved modelscopes and video equipment might produce the desired results. A 16 mm movie camera, with high speed color film, might also give good results. These techniques were not attempted in this study because of time and equipment shortage.

CONCLUSIONS

Six major conclusions have been made concerning this study:

(1) A useful modeling technique has been developed;

(2) Improvements would simplify the technique and make it more effective;

(3) Naked eye viewing through the modelscope is easiest, but produces good results;

(4) Still photographs are more difficult to obtain, but are also of good quality;

(5) Video film of motion over the roadway was not possible with the equipment available, but would be an important improvement over still pictures;

(6) Scale models containing highway signs would be a useful design aid in viewing a finished facility in three dimensions during the design process.

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SCALE MODEL SIGNING TECHNIQUE

by

GARY LEE FOX

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AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

A technique for making scale model highway signs for use in a basic design model was developed. Three methods of viewing the signs through a modelscope were investigated: naked eye; still photographs, both color slides and color prints; and video camera. Photographs of signs taken through the modelscope were compared to photographs of signs taken at location and found to compare favorably. Naked eye viewing and still photographs through the modelscope produced good results, and were considered to be effective design aids. Video camera filming through the modelscope did not produce good results. With necessary modifications, video camera filming could be an important improvement in the modelscope viewing technique by simulating the dynamic nature of the driving task.